

The University of Chicago

ORDOVICIAN SCOLECODONTS

A PART OF A DISSERTATION SUBMITTED TO
THE FACULTY OF THE DIVISION OF THE
PHYSICAL SCIENCES IN CANDIDACY FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF GEOLOGY AND PALEONTOLOGY
DECEMBER, 1935

By
JOHN PAUL GRIES

CHICAGO, ILLINOIS

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INTRODUCTION

Basis of the present study.--The material upon which this study has been based is primarily from the large collection of annelid remains turned over to the writer by Dr. W. H. Shideler, of Miami University. This collection consists of individual collections from over 50 localities in Ohio, Indiana and Kentucky. In age they range from middle Trenton to top of the Richmond. This material has been supplemented by collections made by the writer in southeastern Missouri, southwestern Ohio, and western Ontario. The Missouri material is from the Decorah of Ste. Genevieve County, the Ohio specimens are from the Elkhorn member of the Richmond, and the Ontario material is from upper Ordovician rock from near Toronto. In addition to this material, the writer has had access to the U. P. James collection, to G. B. Grinnell's type specimens, as well as to the collection of F. C. Potter from the Richmond of northern Illinois, and a collection of lower Mississippian forms from Illinois made by H. W. Scott.

Object of this paper.--Croneis and Scott have set up a tentative, uniform classification for all scolecodonts, and have paved the way for further comprehensive study of annelid remains. Further contribution has been made whenever possible by reclassifying, and in some cases, redescribing forms described by early workers. This later work has been done largely on the basis of illustrations given by the original worker, as types are available for only a few species. It has thus been impossible to weed out synonyms, or to say with assurance that some described species are not fragments of larger and still earlier described forms.

With the large amount of material at hand, the writer has endeavored to extend this work. Whenever possible, previously described forms have been redescribed, or the original description emended and refigured. Many new species have been described. No species has been established upon a single specimen, nor upon broken or partially imbedded jaws.

Problems involved.--Restudy of previous work has lead to several problems. Where type specimens have been available, determination of synonyms, emending previous descriptions, and refiguring of specimens has been relatively simple. Foerste's type area has been revisited, and new material collected. In instances where only a general locality and age have been recorded, it has been possible only to compare figures and descriptions with jaws of similar age from other collections. Hinde's first paper has been hard to interpret as his localities and exact horizons are unknown. In addition, he described forms imbedded in matrix, and many crushed and incomplete jaws. His illustrations are poor, and usually show but one perspective drawing of each form described. The writer has visited the Toronto area, and gathered material from collecting areas of known age. Sufficient material has been assembled to show the annelid fauna to be very similar to that found in rocks of similar age near Cincinnati.

Previous work.--The first annelid jaws described from North America were of late Ordovician age. G. B. Grinnell (1877) noticed them in rocks collected near Cincinnati, Ohio. Croneis and Scott have cleaned and restudied Grinnell's types, and have redescribed his forms in light of material used here. G. J. Hinde (1879) figured and described Cincinnati forms from Toronto, and Niagaran and Hamilton forms from western Ontario. The next year he described jaws from the Silurian of England. It is of interest

here only for references to the true appearance of previously described forms. A third paper (1882) deals with Silurian forms from Gotland. A study of these clean, well preserved jaws enabled him to reclassify several Ordovician forms which he had described with only one side exposed. U. P. James (1884) described two Cincinnatians jaws from Warren Co., Ohio. The James collection, now in Walker Museum, contains most of his material.

A. F. Foerste (1888) found annelid remains near Wilmington, Ohio, which he then believed to be of Medina age. He described and figured six species, and noted that both right and left jaws were found, but failed to figure any pairs. Recently¹ Mr. Foerste has said that his original specimens were lost in the 1913 Dayton flood, but that he now believes the beds from which they were taken to be uppermost Ordovician. Parks and Fritz (1922) reproduced the text and plates of Hinde's first paper.

C. R. Stauffer (1933) described many new jaws from the middle Ordovician of Minnesota. He considered it possible to identify different maxillae, even though it may not be certain which belong together in any one assemblage.

F. C. Potter (1933) described many jaws from the upper Richmond of northeastern Illinois. This annelid fauna is dwarfed, and totally lacking in many of the larger species so abundant in typical Cincinnatians rocks. It contains, instead, numerous forms of genera not abundant in Ordovician sediments elsewhere, but now known to be increasingly abundant in later Paleozoic sediments. On the other hand, it is similar to neither of the Silurian faunas described by Hinde. Thus far any effort to correlate these Illinois forms with any other known scolecodont faunas has been unsuccessful.

¹Letter to Dr. Croneis, March 20, 1933.

GENERAL DISCUSSION

Occurrence and distribution.--Recent studies have proven that annelid remains are not the rare paleontological objects that they have heretofore been considered. They have been found in limestone, sandstone, shale, and rocks of intermediate texture, and of widely divergent ages, and it is probable that careful search will reveal them in almost any sedimentary rock examined. Stauffer (1933) has given a summary of their occurrence and distribution within the sediments. G. J. Hinde was first to recognize the widespread distribution of actual annelid remains. He noted their similarity of form and mode of occurrence over wide areas, but made no suggestion as to their possible correlative value.

Correlation.--Study of scolecodonts from the Decorah of Missouri several years ago suggested the possibility that many of the forms belonged to species described by Grinnell, Hinde, and James from Ordovician rocks in other areas. Later, study of the Shideler collection strengthened this hypothesis, especially in regard to the work of Grinnell and James. Recently, comparison of specimens from Toronto with Hinde's figures, and with material from near Cincinnati, has further supported the supposition. It now seems reasonably certain that scolecodont faunas of similar age, distributed over wide areas, are as similar as other associated faunas. Individual variation within a species is no greater among specimens collected a thousand miles apart than among jaws from one exposure. This fact has led in this paper to broad descriptions which include gradational series of scolecodonts under one specific name. Hence, a few forms described by early workers

are here regarded as synonymous, although a study of only the two or three forms involved might easily lead to their separation into distinct species.

Scolecodonts as index fossils.--Scolecodonts are insoluble in acid and small enough to be preserved in well cuttings. This, and their abundance at certain horizons has suggested their use in commercial micropaleontology. One of the objectives of this study has been to determine their value as index fossils. The results are gratifying. The hope that they would prove as useful as ostracodes or foraminifera has not as yet been fulfilled. Nevertheless, even within the half period studied here, several zones are separable on the basis of scolecodonts. Zones are made more upon the basis of the first appearance of a form than upon the presence of a diagnostic short lived species.

Several small differences are noticed between the faunas of the Decorah and the Cynthiana. The Eden, from the small amount of material studied, resembles the Trenton. A conspicuous break comes with the advent in the Maysville of several distinctive forms. The lower Richmond fauna seems similar to the Maysville, but beginning with the Liberty, a knob-like posterior appears on two species of different genera, and other forms are more rugged.

Some of the rarer forms of Paleoleodice may ultimately be usable as definite horizon markers. Several types occur of which only one specimen each has been found. Such forms have not been given new specific names. Due to the relatively long geologic range of individual species of scolecodonts, the correlative value of such aberrant forms is seriously questioned until other identical specimens are found.

CLASSIFICATION

Present status of the problem.--The classification of fossil annelid jaws has long been discussed, due to the fact that only in rare cases are jaws found articulated. In almost all cases the plates are scattered throughout the sediments with no clue as to which forms belong together in the jaw apparatus of any one species. The practice has been to give the different maxillae different generic names, formed by adding "ites" to the name of a similar modern form. Thus it has been necessary to concede that several "species" are present in a complete assemblage.

The problems of such a classification have been discussed by Croneis and Scott. Upon the conclusions reached, they have set up a flexible classification consisting of a group of broadly defined genera. To assure uniform specific descriptions, they have also established a standardized nomenclature for use in the classification. All scolecodonts herein described are placed within their classification. The terms suggested are used in this paper, and the practice of giving a dental formula for each species described has also been followed.

Symmetry.--The most interesting problem raised by this study is the lack of paired jaws as are found in modern annelids. In some fossil species, rights and lefts are found in corresponding numbers, yet in the same sediments are many forms which occur only as right or only as left jaws. All forms of Nereidavus and Arabellites with subquadrate posterior ends and spoon shaped myocoeles (Pl. I, figs. 5, 6, 9-14) are left jaws. Arabellites and Grubie in which a strong ramus and subtriangular myocoele are

developed (Pl. I, figs. 7, 8, 21, 22; Pl. II, figs. 30, 31) are right jaws. Grubia nodosa (Pl. I, figs. 19, 20) has a spoon shaped myocoele and is a left jaw. These are all large, abundant forms. That no mirror image of any of these jaws has been found either in the material at hand or in the literature, makes it seem probable that none will be found.

A comparison of these forms which are all rights or all lefts reveals another striking feature. In many cases the pattern of the dentary, and the arrangement, shape, and number of denticles themselves, on a right jaw, will correspond faithfully with the dentition of a left jaw of similar size. However, the mode of muscular attachment of the two jaws, as reflected in the myocoeles will vary widely. Probably the most striking examples are in Arabellites extensus and Nereidavus extensus (Pl. I, figs. 7-10). In these, the development of the anterior ends differs markedly from all other species, yet the dental formulae and shape of the dentaries correspond closely. However, N. extensus has a subquadrate posterior and A. extensus, a bifurcated posterior end. The two forms are found in corresponding numbers. Due to their size and abundance, they offer a striking suggestion that their complementary anterior development is not mere coincidence, but that there is a close relationship between the two. The smaller genus Elmhurstia displays a similar difference in right and left forms.

All forms of Hyalinaecites occur as true pairs. About equal numbers of rights and lefts are found of Paleoleodice cervicornis and P. spicatus (Pl. II, figs. 15, 16, 38, 39), but the closely allied P. aciculatus (Pl. II, figs. 40, 41) occurs as left jaws only. All species of Grinnellia and Clelandia are right jaws. Hinde (1882) suggested that Grinnellia might represent the under jaw plate. This discussion might be extended to include all

species studied. In general, the larger forms represented by the genera Arabellites, Grubia, and Nereidavus show "pairs" with different muscular attachment, most species of Paleoleodice are found in true pairs; a third group, composed of Grinnellia, Clelandia, and a few species of other genera have no recognizable "mates". A serious problem is presented to students of scolecodonts. In modern forms, and some Paleozoic forms, true jaws are paired; rights and lefts are nearly mirror images. Most fossil jaws occur in so called "pairs" in which right and left jaws are held by different types of muscle attachment. Other forms which seem to be first maxillae apparently are unpaired. Still another group whose position in the jaw is less certain do not seem to be paired. Hinde first encountered this problem in his description of Grubia (Lumbriconereites) obliqua. He concluded:

Though these right and left jaws occur quite detached from each other, I regard them as belonging to the same species from the fact of their correspondence in dimensions and in the character of the denticles whilst the differences in the form of the basal flange and the position of it on the dental ridge are limited to the right and left form respectively.

Stauffer (1933) made no effort to identify right or left jaws. Specific descriptions are so worded as to fit either, but no pairs are figured. Right and left jaws with similar dental formulae, but different outlines and muscular attachments are, however, sometimes included in different species of one genus.

The first serious effort to place the various fossil jaws in their proper positions in the jaw apparatus has been made by Eller (1933). He was impressed by the variation among his Devonian forms, and questioned their exact identification and classification on this basis. This criticism is open to question. In the material studied here, some species are strikingly constant and distinct; others show considerable individual variation, but it is largely confined to outline, and does not affect the true

specific characters such as dental formula or myocoelic outline. This criticism seem valid only in restricted groups. Such large forms as Nereidavus, Grubia and Arabellites are apparently not represented in his material. In the figured Devonian specimens, muscular attachment seems to correspond fairly closely in right and left jaws, even though the dental formulae are somewhat variable. With a few exceptions, this is true of Scott's Mississippian forms. The problem brought up by Ordovician forms is apparently less important in a study of later forms.

The problem which confronts the student may be stated thus: Did some species of Paleozoic worm exist in which the muscular attachments of the right jaws were radically different from the left, while living with them were species whose jaws were the mirror image of each other? To the zoologist and paleontologist this seems impossible. In such a highly developed group, such variation from bilateral symmetry, especially in jaw apparatus, is unknown. The fundamental basis of classification of fossil jaws has been based upon the muscular attachment. It has been assumed that the posterior development is of generic importance, and that since the function of the anterior part is similar in all forms, it might show parallel development in species of different genera.

In modern worms strongly hooked jaws occur in pairs. In many fossil jaws, true pairs are unknown. If forms differing in posterior development are considered as pairs, it is against the principle of bilateral symmetry. Even if forms with similar dentition but different posteriors are considered as upper and lower jaws on one side of the mouth, their mirror images should be found on the other side. If forms existed with a single upper and lower jaw, these should be symmetrical, but no specimen has been found which is truly symmetrical. Or if some sort of radial symmetry

exists, what arrangement must be given to pairs similar to unpaired forms such as Paleoleodice cervicornis and P. aciculatus?

If first maxillae may differ posteriorly, another problem arises. In fossil assemblages and modern forms, these maxillae are truncated posteriorly and rest upon base plates. The bases of Nereidavus, Grinnellia, and some Arabellites seem adapted to such articulation, but species of Arabellites and Grubia in which the dentary extends posteriorly as a spine cannot conceivably have rested on a carrier. If we consider a truncate jaw paired with a jaw of this type, we must either consider the base plate as limited to the left side, or we must eliminate carriers entirely.

Partial answers to these problems are offered by a study of the few known fossil jaw assemblages. J. M. Clarke (1887) figured, but did not describe a Devonian assemblage from New York. His drawing shows "two pairs of serrate denticles, recurved at the tips, also the cusps of an unpaired or radular denticle between them." The specimen is broken and the muscle area concealed. Hinde (1896) figured a specimen from the lower Carboniferous of England. He noted a difference in size and number of denticles, in right and left jaws, but stated that both "pincers" had straight bases where resting on supports. He found no unpaired jaw, though he considered that one might be concealed. Eller (1934) described a Devonian assemblage from New York in which the individual plates are disarticulated. He noted variation among right and left jaws in Devonian and recent forms, but only as it concerns size of the jaw and the number of denticles.

The Shideler collection includes a fourth assemblage. As it is of the same age as other material here described, a careful study of the plates within the assemblage offers a partial answer to the questions raised by a study of isolated jaws.

DESCRIPTION OF AN ORDOVICIAN JAW ASSEMBLAGE

The assemblage herein described is from the basal Liberty formation, as exposed on Addison's Creek, three miles north of Oxford, Ohio. When discovered, it lay ventral side up, well imbedded in limestone, with only three jaw plates discernible. The specimen has been cleaned and remounted as follows: First the ventral side was carefully cleaned. This was heavily coated with balsam, and the assemblage mounted on a glass slide. The rest of the matrix was then removed, leaving the specimen mounted dorsal side up on a drop of balsam, with each jaw plate in an undisturbed position. Both sides are thus available for study.

The assemblage is the most complete thus far described. Eight separate plates are preserved. There are two, and probably three pairs of jaws, and either two or four plates which were probably paired originally. The first maxillae are common forms. The left jaw is similar to Nereidavus glenwoodensis. It has the characteristic truncate end and spatulate myocoele of the genus. A row of denticles extends from the falcus to the center of the posterior end. The right maxilla is probably the species called Grubia extenuata, although this is not certain as the matrix has not been removed from under the falcus. A large ramus protrudes from the outer margin. The dentary extends from the falcus, along the inner margin, and continues as a projection back of the jaw.

Fitting closely against the anterior ends of the first maxillae are two specimens which have been called Paleoleodice. The dentaries face each other, anterior denticle up, and the rami extend outward and posteriorly. The concave dorsal surface of

the smaller jaws fits around the anterior ends of the larger mandibles. The only difference between the second paired jaws is in dental formulae. The left jaw closely resembles P. alternatus in which the first and third teeth are smaller than the second and fourth. The first two denticles only are visible, so definite identification cannot be made without separating the plates. The corresponding right jaw is apparently P. lunatus. The first denticle is missing but the others decrease in size posteriorly.

Anterior to, and fitting closely against this pair, are two plates which do not seem to be mates. The left jaw is another Paleoleodice, in similar orientation. It cannot be identified specifically as the denticles cannot be seen. The right jaw is probably a form which Stauffer has called Hyalinaecites. It rests with the dentary up, and the largest denticle out. The eighth plate lies over the posterior portion of the right first maxilla. The specimen is crushed and poorly preserved, but is similar to forms which have been called Grinnellia scutellata. It lies with the ventral side down, and the dentary parallel to that of the underlying jaw. The truncate posterior end is discernible, but the true shape of the anterior end is still in doubt.

The discovery of this articulated pair of first maxillae offers limited but conclusive evidence that correspondence of dentaries, rather than mode of muscular attachment is the criterion to be used in determining right and left jaws, at least for first maxillae. The absence of any base plate is suggestive, but does not prove that no such forms were originally present. In either case, departure from bilateral symmetry is most pronounced.

The position of the sickle shaped forms of Paleoleodice is established. Only three such jaws are present, but it seems most probable that two pairs were originally present. Among

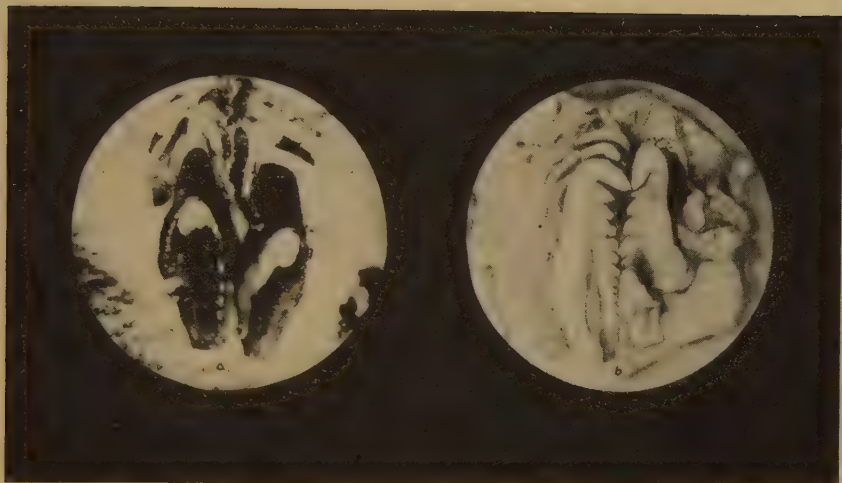


Fig. 3.--Ordovician jaw assemblage. (a) Ventral surface, partly cleaned. (b) Dorsal view of cleaned specimen, whitened. (Both views, x 18)

these maxillae, which exhibit so much variation between specimens, the size and shape of the jaw seems more important than exact correspondence of dental formulae. However, no definite conclusion can be drawn from the limited evidence of this one assemblage.

The specimen of Staufferia plena was probably originally paired. Forms are found which are interpreted as both rights and lefts, although among such simple jaws it has been problematical as to which was right and which left. If the specimen in this assemblage is assumed to be a right jaw, the problem is settled. The posterior ends of the jaws are asymmetrical, as one side extends back to a point. If the jaw be placed with the concave side directed inward, the posterior projection is up.

The orientation of Hyalinaecites is problematical. So much variation exists within this group that the presence here of a single specimen does not warrant a definite conclusion. Even more of a puzzle is the broken Grinnellia. These always appear as right jaws; Hinde considered them under jaw plates. In this assemblage, there is no other jaw with which it may possibly be paired, nor has any form been found elsewhere with which it might hypothetically be mated. A feature of possible significance is that Grinnellia has a truncate end, corresponding to that of the left hand Nereidavus. It is improbable that a short form such as Grinnellia would be set on a carrier opposite such a large jaw.

Study of this assemblage suggests that dental formulae, rather than mode of articulation, determine pairs of first maxillae. Forms of Paleoleodice appear to be second and third maxillae. The relationship of Hyalinaecites and Grinnellia remain in doubt, and no light is thrown on the problem of base plates.

DESCRIPTION OF SPECIES

Genus Arabellites Hinde, 1879

Arabellites Hinde, 1879, Quart. Jour. Geol. Soc. London, 35: 377.

An excellent discussion of this genus has been given by Croneis and Scott (1936), who have restricted the genus somewhat, and designated A. contractus Hinde as the genotype.

Arabellites arcus Gries, n. sp. Right jaw.

Plate I, figures 21, 22.

Jaw plate sub-rhomboidal, extended anteriorly into a stout, undenticulated falcus, strongly recurved in the plane of the dentary. Denticles set nearly at right angle to plane of jaw. Outer margin broadly convex, inner margin convex, extending from tip of falcus to a point one half to two thirds back along the length of the jaw, at which point it curves abruptly toward the dentary. Dentary extends back beyond the main portion of the jaw as a narrow, tapering projection. Myocoele open, extending as a broad crescent from tip of ramus forward nearly as far as the first denticle, then posteriorly the full length of the dentary.

Dental formula: $\frac{12-16}{1s, 2L-16m}.$

Dimensions: length 2.35 mm., maximum width .9 mm.

Occurrence: Cynthiana to top of Richmond. Type specimen from Fairmount formation, Clover Creek, north of Bethel, Ohio.

Remarks: Abundant, but quite variable in size and proportions. Type specimen is one of the most robust, the variety described represents the other extreme of a completely gradational series. Forms are intermediate between the short heavy type with

broad falcate arch, and the long slender form in which the first denticle is rather close to the falcus and the ramus is in the anterior half of the jaw.

Arabellites arcus var. tortus Gries, n. sp. Right jaw.

Plate I, figures 1, 2.

Jaw plate narrow, extended anteriorly into small falcus, slightly recurved, and set obliquely to major plane of jaw. Inner margin nearly straight, outer margin marked by narrow laterally directed ramus at about midpoint of jaw. Dentary extended back beyond main portion of jaw as long slender bar. Dentary twisted so that anterior denticles are set at right angle to major plane of jaw. Ventral surface marked by open, hook-shaped myocoele.

Dental formula: $\frac{12-16}{1s, 2L-16m}$.

Dimensions: length 1.62 mm., maximum width .56 mm.

Occurrence: Cynthiana to top of Richmond. Type specimen from Liberty formation, Flat Fork, Oregonia, Ohio.

Remarks: Forms of this extreme type approach those of the genus Paleoleodice. In Paleoleodice, however, the dentary must lie in the plane of the jaw, not at a pronounced angle to it.

Arabellites cornutus Hinde, 1879. Left jaw.

Plate I, figures 17, 18.

Arabellites cornutus Hinde, 1879, Quart. Jour. Geol. Soc. London, 35: 377, pl. 18, figs. 13-15.

Jaw relatively wide, truncate, the lower basal edge curved, with a more or less prominent, knob-like elevation in the center which is the widest part of the base, the upper edge is nearly straight, with a deep furrow just below the teeth extending from the middle to the posterior extremity, beneath which a rounded elevation is sometimes present. In front is an extremely large curved hook, and on the nearly straight upper edge is a series of small teeth, from eleven to twenty in number; those towards the front are conical, whilst back further they gradually diminish in size and become rounded.

Emended description. Jaw plate oblong, extended anteriorly into a long, slender falcus. Posterior part is diagonally truncate. Outer margin marked medially by a small ramus. Inner margin straight. Dentary, inclined to plane of jaw, extends from shank of falcus back to center of posterior end. 8 to 12 small denticles; those anterior are pointed, those posterior are node-like. Ventral surface marked by a large, spatulate myocoele.

Dental formula: $\frac{8-12}{1s, 2L-12m}$.

Dimensions: figured specimen, length 1.35 mm., width .56.

Occurrence: Cynthiana to top of Richmond. Figured specimen from Liberty formation, Flat Fork, Oregonia, Ohio.

Remarks: This form is abundant. First true dentical is typically smaller, but may be as large as the next in the series.

Arabellites extensus Hinde, 1880. Right jaw.

Plate I, figures 7, 8.

Arabellites extensus Hinde, 1880, Quart. Jour. Geol. Soc. London, 36: 374, pl. 14, fig. 12.

The main portion of the jaw formed of a relatively thick, somewhat concave plate with a prominent knuckle-shaped posterior extremity; the basal margin is curved, with a stout sharp pointed anterior hook oblique to the main portion; the upper margin is prolonged backwards to form an extended arm on which there is a series of recurved denticles. The number of denticles altogether on the upper margin is about 15.

The tooth-bearing extension renders this species very distinct from any of the preceding. A form closely allied to, if not identical with the present species also occurs in the Cincinnati group at Toronto, but the only example I have of it is not sufficiently perfect to allow of description.

Forms resembling Hinde's figure are common in the Cincinnati area, and have been found near Toronto. His statement that he observed similar forms at Toronto leaves little doubt that the Cincinnati and Silurian forms are identical. Hence, all forms will be assigned to this one species.

Emended description. Main portion of jaw cylindrical,

extended forward and recurved to form a long, strong falcus. Posterior end bifurcated; the inner margin is a continuation of the dentary, the outer margin is twisted to form a small ramus. True dentary present only on posterior third of jaw, and is set with 6 to 12 small denticles. Two to four long, sharp, wide-set denticles appear on the shank of the falcus. Myocoele narrow, crescentic, and outlined by a narrow rim.

Dental formula: $\frac{8-16}{1-4L, 5-16s}.$

Dimensions: length 2.2 mm., maximum width 1.3 mm..

Occurrence: Mt. Hope to top of Richmond, Maysville of Toronto. Type from Liberty formation, Oregonia, Ohio.

Remarks: A specialized Arabellites in which the shank has become greatly enlarged. The anterior denticles have migrated to the shank. There is little doubt that this jaw is the mate of N. extensus, despite their different posterior development.

Genus Clelandia Croneis and Scott, 1936.

This genus has been set up to include species placed by Hinde in the poorly defined genus Oeononites. Genotype has been designated as Clelandia (Oeononites) radula (Hinde) from Gotland.

Clelandia recurvata Gries, n. sp. Right jaw.

Plate II, figures 46, 47.

Jaw sub-triangular, plane of jaw more or less twisted. Inner margin set with 14 to 16 denticles which decrease in size posteriorly. First denticle extended into short, claw-like falcus. Posterior quarter of dental ridge undenticulated, set at angle to rest of dentary, and terminated by a small knob-like process. Jaw has greatest width near midpoint, where outer margin is marked by a small, forward directed ramus. Dorsal surface smooth, warped. Ventral surface marked by a long open myocoele, around

the posterior margin of which a strong flange is developed.

Dental formula: $\frac{14-16}{1L, 2s-16m.}$

Dimensions: length 1.46 mm., maximum width .84 mm.

Occurrence: Whitewater and Liberty formations. Type specimen from Liberty formation, Flat Fork, Oregonia, Ohio.

Remarks: Characterized by knob-like process at posterior.

Clelandia trigonalis Gries, n. sp. Right jaw.

Plate II, figures 17, 18.

Jaw relatively flat, triangular. Inner margin more or less straight, set with 15 to 18 small, nearly even denticles, which decrease in size posteriorly. Jaw has greatest width near midpoint, where the outer margin is marked by a small, forward directed ramus. Dorsal surface slightly concave anteriorly; first denticle usually somewhat longer than the others. Ventral surface marked by a narrow, ovate myocoele.

Dental formula: $\frac{15-18}{1L, 2s-18m.}$

Dimensions: length 1.05 mm., maximum width .44 mm.

Occurrence: Decorah of Missouri and Jessamine formation of Kentucky. Type from Ste. Genevieve County, Missouri.

Remarks: Differs from genotype in myocoele outline.

Genus Elmhurstia Groneis and Scott, 1936.

This genus includes forms noted by Hinde in the Silurian, and found to be abundant in the Mississippian by Scott.

Elmhurstia nododentata Potter 1933. Right jaw.

Plate II, figures 3, 4.

Elongate, sub-rectangular jaws possessing node-like teeth. The inner lateral margin is concave except near the posterior end where a flange from the ventral surface produces an off-set and proximal tip as in E. recurvirostris. This species is almost identical with E. recurvirostris, but it differs

in having the dentary on the inner edge in the major plane of the jaw, and in having the denticles curved inward. Posteriorly, however, where the dentary curves outward it is inclined to the major plane of the jaw and the denticles point upward. The falous-like first denticle points inward rather than upward.

Dental formula: $\frac{24-40}{11, 2-32s.}$

Occurrence: Fairmount and Liberty in Cincinnati area.

Figured specimen from Liberty, Flat Fork, Oregonia, Ohio

Elmhurstia regularis Potter 1933. Left jaw.

Elongate, sub-rectangular jaws marked anteriorly by a falous-like tooth. The inner lateral margin is straight for most of its length, but it is concave near the anterior and posterior ends. Posteriorly on the ventral surface is developed a flange which extends inward past the dentary to form the inner margin. Located along the inner edge in the major plane of the jaw is the dentary; the sharp, fragile teeth inward, they are so fragile that on most specimens many have been broken away. In the posterior one-sixth of the jaw the dentary continues along the inner edge although the flange from the ventral surface projects beyond it inwardly. In its central portion the outer lateral margin is straight, but it is convex at each end. The anterior end is curved; the posterior end is truncated along the outer edge and it possesses a blunt termination. The dorsal surface is plano-concave; on it is located a short groove parallel to the dentary posteriorly and open proximally. The ventral surface is flat. Located posteriorly on the ventral surface diagonal to the width of the jaw is the myocoele; its anterior end is near the outer edge. Posteriorly it is uninclosed.

Dental formula: $\frac{20-50}{11, 2-44s.}$

Occurrence: Fairmount and Liberty of Cincinnati area.

Remarks: Exceedingly rare, perhaps due to small size.

Genus Grinnellia Groneis and Scott, 1936.

This genus has been set up to include a large group of subquadrate jaws considered by Hinde to be lower jaw plates.

Grinnellia (Arabellites) quadrata (Hinde) 1879. Right jaw.

Plate I, figures 15, 16.

Arabellites quadratus Hinde, 1879, Quart Jour. Geol. Soc. London, 35: 379, pl. 19, fig. 14.

Emended description (Cronels and Scott). Jaw subquadrate, nearly flat. Inner lateral margin denticulated, outer lateral margin nearly parallel to dentary, but marked at the anterior end by a long outwardly directed ramus. Ventral surface open, marked by a narrow myocoele extending into dentary. A flange, increasing in width posteriorly, bounds the myocoele.

Dental formula: $\frac{12-16}{11-16m}$.

Dimensions: figured jaw, length to tip of ramus 3.25 mm., width of jaw plate 1.54 mm.

Occurrence: Cynthiana to Liberty. Figured specimen from Cynthiana formation, one mile west of Augusta, Kentucky.

Remarks: First denticle is usually worn or missing.

Grinnellia (Arabellites) scutellata (Hinde) 1879. Right jaw.

Plate II, figures 34, 35.

Arabellites scutellatus Hinde, 1879, Quart. Jour. Geol. Soc. London, 35: 379, pl. 19, fig. 16.

Upper portion of the jaw subquadrate, with a prolonged, gradually narrowing base; surface slightly convex, with a very prominent protuberance at the lower posterior angle; the nearly straight upper border carries eleven teeth, of which the first is pointed, somewhat longer than the rest, and projects outwards; the others are subequal rounded teeth.

Emended description: Jaw subquadrate, nearly flat. Inner margin denticulated, set with row of small teeth, the first of which may be somewhat longer than those following. Jaw widest at anterior end, which is projected outward to form a triangular ramus. Outer margin straight to concave. Posterior portion of jaw subquadrate. Dentary extends from anterior denticle posteriorly, and appears to migrate to dorsal side of the jaw, due to the development of flange around posterior portion of myocoele.

Dental formula: $\frac{8-14}{11-14m}$.

Dimensions: figured jaw, length 1.1 mm., width .73 mm.

Occurrence: Decorah of Missouri, Cynthiana to top of Richmond in Cincinnati area, Maysville of Toronto region.

Remarks: Arabellites erectus Stauffer appears to be synonymous with this form.

Grinnellia varians Gries, n. sp. Right jaw.

Plate II, figures 32, 33.

Jaws subtriangular, inner margin set with row of sharp denticles which may vary in size and number. First denticle is usually developed into a hook. Outer margin angular, the jaw is widest at about its midpoint. The margin is variable, since it is extremely fragile and usually more or less broken. Posterior part of jaw truncate, as in G. scutellata. Ventral surface marked by a large open myocoele which extends up into the dentary. Myocoele bounded by a wide flange, which is not so rugged as in the other species of the genus.

Dental formula: $\frac{8-12}{11, 2s-12m}.$

Dimensions: length .84 mm., maximum width .57 mm.

Occurrence: Cynthiana to top of Richmond. Type specimen from Fairmount formation, Clover Creek, Bethel, Ohio.

Remarks: Abundant, but always poorly preserved.

Genus Grubia Croneis and Scott, 1936.

This genus includes jaws previously assigned to Arabellites, Lumbriconereites, and Protarabellites, but which bear close relationship to one another. Considerable variation among forms of this genus makes it difficult to separate species, as no two specimens have identical flanges on the inner margin. Some are wide and ridged, others fold under so that the individual form resembles the genus Paleoleodice. The size and shape of the ramus also varies. Division into species has been done largely on the basis of dental formulae, although variations in posterior development have been considered in determining two species.

Grubia bifurca Gries, n. sp. Right jaw.

Plate I, figures 3, 4.

Elongate, subtriangular scolecodonts, narrowed posteriorly. Inner margin convex, characterized by a wide flange. Outer margin marked by a large, posteriorly directed ramus. Pre-ramal slope straight to concave anteriorly, ramal arch acute. Dentary extends upward from inner margin obliquely; straight posteriorly, but curved out slightly on the anterior end. Anterior two denticles large, curved upward and slightly posteriorly, followed by 3 or 4 minute teeth, then a series of 10 to 12 small teeth decreasing in size posteriorly. Ventral surface marked by triangular myocoele.

Dental formula: $\frac{15-18}{1-2L, 3-6m, 7s-18m.}$

Dimensions: length 1.92 mm., maximum width .9 mm.

Occurrence: Decorah of Missouri, Cynthiaana to top of Richmond. Type from Decorah, Ste. Genevieve County, Missouri.

Grubia contorta Gries, n. sp. Left jaw.

Plate II, figures 32, 33.

Elongate jaw, narrowed posteriorly. Inner margin broadly convex, outer margin convex, marked at its midpoint by a widening of the basal flange. Dentary extends from outer margin posteriorly to inner margin anteriorly, then is sharply recurved around anterior end of jaw. Dentary at right angle to major plane of jaw. Anterior 2 or 3 denticles large, then comes a series of increasing and decreasing denticles in which the largest is near midpoint of jaw. Ventral surface marked by a spatulate myocoele.

Dental formula: $\frac{10-14}{1L-3s, 4m-6s-14m.}$

Dimensions: length .9 mm., maximum width .34 mm.

Occurrence: Cynthiaana. Type from Augusta, Kentucky.

Remarks: This form is quite similar to an unnamed species

of Protarabellites described by Stauffer (1934, p. 1193).

Grubia falcata Gries, n. sp. Right jaw.

Plate I, figures 23, 24.

Large, elongate jaws, narrowed posteriorly. Inner margin convex, characterized by a wide flange; outer margin marked at midpoint by a large, posteriorly directed ramus. Pre-ramal slope broadly concave; ramal arch broadly obtuse. Dentary curved slightly, an upward extension of the inner margin; oblique to the major plane of the jaw. Denticles more or less conical, inclined posteriorly. Anterior denticle is extended into a large falcus, set with 4 to 6 small nodes, or undeveloped teeth. 8 to 10 true denticles follow, decreasing in size posteriorly. Ventral surface marked by a large triangular myocoele in the posterior portion.

Dental formula: $\frac{18-20}{11, 2-6m, 7-13s, 14-20m}.$

Dimensions: length 2.2 mm., maximum width .78 mm.

Occurrence: Decorah of Missouri, Jessamine to top of Richmond. Type specimen from Decorah, Ste. Genevieve Co., Mo.

Remarks: Jaws have been found up to 10 mm. in length.

Grubia (Arabellites) hindei (James) 1884. Right jaw.

Plate II, figures 30, 31.

Arabellites hindei James, 1884. Jour. Cin. Soc. Nat. Hist. 7: 148, pl. 7, fig. D.

Jaw with a prominent, prolonged tooth in the anterior end, which stands at nearly right angles with the jaw, and is slightly curved inward at the point; just below the point is a regular curve forward and downward to the base of the jaw. Back of the hooked-tooth are six small but conspicuous teeth, three of them standing erect, the other three slope backward, the middle one (longest of the six) at a lower angle than the others; back of the sixth dentation, near the posterior end, is a slight elevation in the jaw which may be an immature tooth. In the posterior end of the jaw is an indentation extending to near the middle, causing an apparent pointed projection of the base. A longitudinal ridge, about the middle of the jaw, extends from the posterior end of the base of the

anterior long tooth. Color of the jaw a shiny, jet black.

The very fine specimen used for this description is partly imbedded in rock at the posterior end, but the other end stands out free. It was found by the writer in the bed of a "run" in Warren Co., O., about four miles from Loveland, Clermont Co., in the Cincinnati group.

This specimen has been removed from the matrix by Scott, and has proven to be similar to Grubia (Lumbriconereites) obliqua from Gotland. G. hindei is here limited to Ordovician forms.

Emended description. Slender, subtriangular jaws, extended posteriorly. Inner margin convex, characterized by a flange which may be wide or largely underturned. Outer margin marked at midpoint by large, outward directed ramus. Pre-ramal slope slightly concave, ramal arch broad. Dentary extends upward obliquely from inner margin, and curves outward anteriorly. 16 to 18 large denticles, decreasing in size posteriorly. First denticle is an extension of anterior part of jaw, and appears as a hook from ventral view. Ventral surface marked by large myocoele. Posterior part of jaw more slender and extended than G. robusta.

Dental formula: $\frac{16-18}{1-6L, 7s-18m.}$

Dimensions: figured jaw, length 1.1 mm., width .45 mm.

Occurrence: Decorah, Cynthiaana to top of Richmond, and Maysville of Toronto. Figured specimen from Decorah of Missouri.

Grubia nodosa Gries, n. sp. Left jaw.

Plate I, figures 19, 20.

Elongate jaw, narrowed posteriorly. Inner margin relatively straight, marked about one-third of the way forward by a slight lateral flange. Outer margin marked at midpoint by a small semi-circular ramus-like flange. Dentary extends from posterior extremity forward along center of jaw. Anteriorly it migrates to the inner margin, and swings around the anterior end of the jaw. Denticles set at right angle or slightly obliquely to

plane of jaw. First and second denticles large, the next 3 to 5 are small and poorly developed. Then 12 to 16 conical denticles which increase in size to near the midpoint, then decrease posteriorly. Posterior extremity of jaw characterized by knob-like process. Ventral surface marked by open, spatulate myocoele.

Dental formula: $\frac{10-22}{1, 2L, 3-5m, 6m-10s-20m.}$

Dimensions: length 2.2 mm., maximum width .62 mm.

Occurrence: Liberty to top of Richmond. Type specimen from Liberty formation, Flat Fork, Oregonia, Ohio.

Remarks: Similar to N. glenwoodensis, but posterior flanges have apparently been absorbed. Rarely found together.

Grubia robusta Gries, n. sp. Right jaw.

Plate I, figures 17, 18.

Elongate, robust jaws. Inner margin wide, convex. Outer margin marked by short strong ramus. Dentary, which is set at right angle or steeply inclined to plane of jaw, extends from anterior end as a wide upper projection of the inner margin, and continues posteriorly to form a blunt projection. Denticles decrease in size posteriorly. Myocoele subtriangular, open.

Dental formula: $\frac{16-20}{1L-18m.}$

Dimensions: length 1.8 mm., maximum width .67 mm.

Occurrence: Liberty to Elkhorn. Type specimen from Whitewater formation, Dodges Creek, north of Oxford, Ohio.

Remarks: Similar to G. obliqua from Gotland. Distinguished from G. hindei by the wide, truncated inner margin.

Genus Hyalinaecites Stauffer, 1933.

Hyalinaecites Stauffer, 1933, Bull. Geol. Soc. Amer., 44: 1202.

This genus was founded to include the dental elements

resembling closely those in the recent genus Hyalinaecia.

Hyalinaecites coronatus Gries, n. sp. Right and left jaws.

Plate II, figures 28, 29.

Jaw consists primarily of a dentary with extended flanges. Dentary crescentic, set with large, rounded denticles decreasing in size posteriorly. Margin on convex side widest at midpoint, giving the lateral view a triangular appearance. Other margin gently convex. Ventral side open; myocoele extends into denticles.

Dental formula: $\frac{10-16}{11-16m}$.

Dimensions: length 1.4 mm., maximum width .5 mm.

Occurrence: Decorah to top of Richmond. Type from Decorah, North Gabouri Creek, Ste. Genevieve County, Missouri.

Remarks: Considered by Croneis and Scott to be paragnaths.

Genus Nereidavus Grinnell, 1877.

Grinnell gave no generic description. Croneis and Scott have emended the description of the genotype to serve as a generic description. N. varians, when cleaned, was too incomplete for further specific description. Grinnell's other form has been cleaned and described by Croneis and Scott as N. grinnelli.

Nereidavus compressus Gries, n. sp. Left jaw.

Plate II, figures 26, 27.

Jaw elongate, truncate obliquely posteriorly. Inner and outer margins gently convex, converging at front to form a falcus. No true ramus present. Dentary at right angle to jaw posteriorly. It continues forward through the center of the jaw, and migrates to inner margin anteriorly. 16 to 20 sharp denticles, small on falcus arch, increasing in size toward the midpoint, then decreasing posteriorly. Ventral surface marked by a large, spatu-

late myocoele in posterior portion.

Dental formula: $\frac{16-20}{1L, 2-6s, 7s-20m.}$

Dimensions: length 1.24 mm., maximum width .45 mm.

Occurrence: Fairmount. Type from Bethel, Ohio.

Remarks: Similar to N. glenwoodensis, but more fragile.

Nereidavus extensus Gries, n. sp. Left jaw.

Plate I, figures 9, 10.

Elongate, biramal jaws; posterior end subquadrate. Anterior end extended into long strong falcus. Outer margin slightly convex, marked posteriorly by small rounded ramus. Inner margin concave anteriorly and posteriorly from ramus, which is located in posterior portion of jaw. Dentary extends forward from middle of truncate end, approaches inner margin one-third of way forward, then bends abruptly toward center of jaw, where it merges with the falcus. Posterior part set with small, conical, close set denticles, posteriorly directed. Anterior portion set with wide spaced, well developed, spike-like denticles which extend well onto falcus. Ventral surface marked by spoon shaped myocoele.

Dental formula: $\frac{8-16}{1-4L, 5-16m.}$

Dimensions: length 2.2 mm., maximum width .67 mm.

Occurrence: Richmond and Maysville of Cincinnati area. Maysville of Toronto. Type from Liberty formation, Oregonia, O.

Remarks: Although similar to Arabellites extensus, the truncate end places it definitely in the genus Nereidavus.

Nereidavus grinnelli Croneis and Scott, 1936. Left jaw.

Plate I, figures 5, 6.

Biramal, subquadrate jaws. Inner margin convex, marked posteriorly by a small rounded secondary ramus. Outer margin concave, marked by large primary ramus which is anteriorly directed. Dorsal surface divided longitudinally by a dentary

curved parallel to the margins; starting centrally at the subquadrate posterior end, but migrating to the inner margin anteriorly. 20-26 denticles set at right angle to plane of the jaw, and are inclined slightly posteriorly. Anterior end of jaw is extended into a large falcus, on the inner margin of which a large, secondary, curved tooth is developed. Between this first denticle and the next true tooth, a series of 4 to 6 small nodes may be present. 14 to 16 small denticles follow decreasing in size regularly posteriorly. Myocoele large, open, including most of posterior half of ventral side.

Dental formula: $\frac{19-26}{1L, 2-6m, 7s-26m.}$

Occurrence: Decorah to Elkhorn. Figured specimen from Decorah formation, Ste. Genevieve County, Missouri.

Nereidavus (Protarabellites) glenwoodensis (Stauffer) Left jaw.

Plate I, figures 11, 12.

Protarabellites glenwoodensis Stauffer, 1933, Bull. Geol. Soc.

Amer., 44: 1191, pl. 61, figs. 19, 24.

Jaw, elongate, with the posterior side of the subrhombic base, short. Upper surface of outer flange, with a broad groove-like concavity. Inner flange has similar groove but is distorted by a downward bend of the inner angle. Denticulated ridge, thick, strong, and having a series of 22-24 short, stout, backward-directed teeth. At the anterior end the toothed ridge curves rapidly inward and terminates in a slender elongate tooth, or hook. Outer margin of the hook continues downward into margin of the inner flange.

To this should be added, ventral surface marked by an open, spatulate myocoele in posterior portion.

Dental formula: $\frac{20-25}{1, 2L, 3-6s, 7s-25m.}$

Occurrence: Glenwood of Minnesota, Decorah of Missouri, Jessamine to top of Richmond. Type from Glenwood of Minnesota.

Remarks: Possibly synonymous with Arabellites dactylus Hinde, from Toronto area.

Genus Paleoleodice Croneis and Scott, 1936.

Established to include a group of closely related sickle shaped, and sub-triangular forms previously included under the genera Arabellites, Lumbriconereites, and Oenonites.

Paleoleodice (Arabellites) aciculatus (James) 1884. Left jaw.

Plate II, figures 40, 41.

Arabellites aciculatus James, 1884, Jour. Cin. Soc. Nat. Hist.,

7: 148, pl. 7, fig. E.

The jaw plate has a comparatively long hook anteriorly, curving quite sharply inward. A regular curve from the point of the hook to the upper margin of the jaw and to the first dentation, forming almost a semi-circle, where the outline arches gently back to the posterior extremity. Seven short teeth, of irregular lengths, having a marked backward slope occupy this upper arched portion of the jaw. The curved outline from the top of the hook in front downward extends to a pointed shank below, about one-third the distance backward, where the lower margin curves upward, then backward to the posterior extremity. Quite a sharply defined ridge extends from the point of the hook to the posterior end.

To the above should be added, ventral surface marked by a narrow crescentic myocoele, which extends from the tip of the ramus to the posterior end of the dentary.

Dental formula: $\frac{7-12}{1, 2s, 3L, 4s-12m.}$

Occurrence: Fairmount to top of Richmond. Type from Warren Co., Ohio. Figured jaw from Liberty, Oregonia, Ohio.

Remarks: James' type is missing, but the illustration and description leave no doubt as to the identity of the species.

Paleoleodice alternatus Gries, n. sp. Left jaw.

Plate II, figures 42, 43.

Slender, crescentiform jaws. Outer margin concave, marked anteriorly by a short, slender, posteriorly directed ramus which is approximately at right angle to dentary. Inner margin convex. Dentary curved, parallel to inner margin, and set with 10 to 12 irregular denticles. Second and fourth teeth smaller than first, third, and fifth. Dorsal surface concave; ventral surface convex; marked by a large crescentic myocoele which extends from the tip of the ramus to the posterior end of jaw.

Dimensions: length 1.6 mm., maximum width 1.04 mm.

Dental formula: $\frac{10-12}{1L, 2s, 3L, 4m, 5s-12m.}$

Occurrence: Decorah of Missouri, Fairmount to top of Richmond, Toronto, Type from Decorah formation, Missouri.

Paleoleodice (*Arabellites*) *cervicornis* (Hinde) R. and I. jaws.

Plate II, figures 36-39.

Arabellites cervicornis Hinde, 1879, Quart. Jour. Geol. Soc. London, 35: 379, pl. 19, figs. 8, 12.

Jaws very variable in form, sometimes crescentiform, with a short angular extension in front, at other times elongated and extended below the middle of the jaw; in front there are from two to three relatively large divergent teeth, followed by a series of from 4 to 7 minute acute teeth. Length $5/8$ l.

This description seems to include two or possibly three species, each so constant in form as to be a separate species. Reference to a short angular extension is considered to refer to what is here called *Paleoleodice spicatus*. *Paleoleodice aciculatus* might also be included in the description. The form illustrated by Hinde possesses three large divergent teeth at the anterior end. It is proposed to limit *P. cervicornis* to include only this form.

Emended description: Jaw subtriangular, with a distinct pointed ramus on the anterior half of the outer margin. Inner margin set with denticles of varying sizes. Anterior portion of dentary marked by three large, curved, divergent teeth, followed by 4 to 7 small denticles. Dorsal surface concave, ventral side convex, marked by a crescentic myocoele extending from tip of the ramus to the posterior extremity of the dentary.

Dental formula: $\frac{7-9}{1-3L, 4s-9m.}$

Occurrence: Mt. Hope to top of Richmond. Figured jaw from Whitewater formation, Dodges Creek, Oxford, Ohio.

Paleoleodice concavus Gries, n. sp. Left jaw.

Plate II, figures 11, 12.

Jaw subtriangular. Anterior end extended into a small, inwardly directed falcus, posterior end blunt. Outer margin marked by a broad pointed ramus. Inner margin set with row of irregular denticles. Dorsal surface concave, ventral side convex, marked posteriorly by a sub-triangular myocoele.

Dental formula: $\frac{16-18}{1L, 2, 3m, 4s, 5-7m, 8s-18m}$.

Dimensions: length .67 mm., maximum width .34 mm.

Occurrence: Liberty. Type from Flat Fork, Oregonia, O.

Remarks: Characterized by large denticle in row of minute denticles in anterior portion of dentary.

Paleoleodice (Arabellites) crenulatus (Hinde) 1879. Left jaw.

Plate II, figures 9, 10.

Arabellites crenulatus Hinde, 1879, Quart. Jour. Geol. Soc. London, 35: 379, pl. 19, fig. 9.

Main portion of jaw nearly straight, flattened, and gradually tapering; in front is a short, blunted rod-like extension at right angles to the toothed part of the jaw, which carries 8 stout denticles, the first of which is small and claw-shaped, the others triangular and acute. Abundant.

To this should be added, ventral surface marked by a narrow, angular myocoele extending from tip of ramus to end of jaw.

Dental formula: $\frac{6-10}{1s, 2L, 3s-10m}$.

Dimensions: figured jaw, length .8 mm., width .6 mm.

Occurrence: Mt. Hope to top of Richmond, Channahon of Illinois, Toronto area.

Remarks: Tip of ramus may be curved or straight.

Paleoleodice irregularis Gries, n. sp. Left jaw.

Plate II, figures 5, 6.

Robust, crescentic forms, outer margin slightly concave posteriorly. Anterior portion marked by a sharp, spine-like ramus, which is curved slightly and directed toward the posterior end. Ramus approximately at right angle to dentary. Dentary curved, parallel to the inner margin, and set with 10 to 12 irregular denticles. First and third denticles are much smaller than second, fourth and fifth. Dorsal surface concave; ventral surface convex and marked by a crescentic myocoele which extends from tip of ramus to posterior extremity of dentary.

Dental formula: $\frac{10-12}{1s, 2L, 3m, 4, 5L, 6s-10m.}$

Dimensions: length 1.11 mm., maximum width .73 mm.

Occurrence: Decorah of Missouri, Mt. Hope to top of Richmond, Maysville of Toronto. Type from Decorah of Missouri.

Paleoleodice (Arabellites) lunatus (Hinde) R. and L. jaws.

Plate II, figures 7, 8, 25.

Arabellites lunatus Hinde, 1879, Quart. Jour. Geol. Soc. London, 35: 378, pl. 19, figs. 4-6.

Jaw sickle- or crescent-shaped, one end pointed, the other extended into a rod-like prolongation, the front surface concave. On the curved outer rim of the crescent are from ten to twelve short rounded teeth, the two anterior ones are generally slightly larger and somewhat divergent from the others; in one instance, however, those anterior teeth are not present. In fig. 4 the length of the toothed portion is 1 line, and of the projection $3/4$ line; fig. 5 is $1\frac{1}{2}$ line in length; and fig. 6 is $7/8$ line.

This is a very abundant form and shows a good deal of variation in different examples.

As noted by Hinde, this type of jaw exhibits a greater degree of variation than most others. Variation in dental formula, ramal arch and angle, length of ramus, and the angle which the dentary makes with the plane of jaw, combine to make this group difficult to classify. Differences in dental formulae are the most constant variations. Division into species has been

attempted only in a general way, upon these variations. In this paper, Paleoleodice lunatus is limited to those forms having a series of short teeth, decreasing in size posteriorly.

To Hinde's description should be added, ventral surface convex, marked by a narrow crescentic myocoele extending from tip of ramus to posterior extremity of jaw.

Dental formula: $\frac{8-16}{11-16m}$.

Occurrence: Decorah of Missouri, Cincinnati of Toronto and Cincinnati area. Figured jaws from Decorah of Missouri.

Paleoleodice spicatus Gries, n. sp. Right and left jaws.

Plate II, figures 15, 16.

Jaw angular, consisting only of a dentary and spike-like ramus. Dentary straight or slightly curved, set with 8 to 12 teeth of variable size. Anterior denticle is long and somewhat curved; set nearly perpendicular to dentary, rather than forming a true falcus. This is followed by 2 to 3 minute teeth, which are in turn followed by another long denticle and 4 to 6 small teeth, directed posteriorly. Ramus spike-like, set anterior extreme of jaw, and forming a right angle with both the dentary and first denticle. Ventral surface narrow, marked by an angular slit-shaped myocoele which extends from tip of ramus to posterior end of dentary. Posterior tip of dentary usually missing.

Dental formula: $\frac{8-12}{11, 2, 3s, 4L, 5s-12m}$.

Dimensions: length .64 mm., width .6 mm.

Occurrence: Maysville and Richmond of Cincinnati area.

Type specimen from Whitewater formation, Dodge Creek, Oxford, O.

Remarks: Three small denticles may occasionally separate the two large denticles, but this is not considered to be of specific importance.

Paleoleodice spinosus Gries, n. sp. Left jaw.

Plate II, figures 1, 2.

Jaw small, crescentiform, with short, spike-like ramus posteriorly directed. Inner margin convex, set with 8 to 12 small, irregular denticles. Posterior portion of jaw pointed. Dorsal surface concave, ventral surface marked by a narrow myocoele. Ramus slightly curved from major plane of the jaw.

Dental formula: $\frac{8-12}{11, 2m-3s-12m}$.

Dimensions: length .79 mm., maximum width .56 mm.

Occurrence: Fairmount to top of Richmond. Type from Liberty formation, Flat Fork, Oregonia, Ohio.

Genus Scottia Potter, 1933.

Genus includes a group of ovate, flat jaw plates of dubious relationships. They may possibly be dermal plates.

Scottia ovata Potter, 1933.

Plate II, figures 23, 24.

Subovate jaws with both ends gently rounded. The inner and outer lateral margins are convex; the inner edge is set with denticles which are longer at the center and decrease slightly in size toward each end. The dorsal and ventral surfaces are ribbed, but flat and not distinguishable.

Dental formula: $\frac{16-24}{1-17s}$.

Occurrence: Channahon of Illinois, Waynesville and Liberty of Cincinnati area. Figured jaw from Liberty, Oregonia, O.

Remarks: In uncrushed jaws a slotlike myocoele is present. Ribbing is not always present on both sides.

Genus Staufferia Croneis and Scott, 1936.

This genus includes clawlike, non-denticulate scolecodonts. Staufferia (Hyalinaecites) plena (Stauffer) R. and L. jaws.

Plate II, figures 44, 45.

Maxillae, slender, smooth, curved inward at the top and with a pointed tip. Bulge on the inner surface is well down toward the base. Cross section is sub-circular to oval.

To this should be added, myocoele present in posterior end.

Occurrence: Decorah of Minnesota and Missouri, Mt. Hope to top of Richmond in Cincinnati area. Type from Minnesota.

Remarks: This form appears similar to the genotype, but Hinde figured none from the Ordovician, so Stauffer's species is here used for Ordovician forms.

Staufferia spinosa Gries, n. sp.

Plate II, figures 9, 10.

Non-dentate, elongate, slightly curved scolecodonts. Myocoele on inner margin is hour glass shaped, forming a secondary flange on the inner margin just posterior to the midpoint.

Dimensions: length 1.12 mm, maximum width .35 mm.

Occurrence: Liberty. Type from Flat Fork, Oregonia, O.

Remarks: Rare, but very constant in outline.

Genus Staurocephalites Hinde, 1879.

Staurocephalites Hinde, 1879. Quart. Jour. Geol. Soc. London, 35.

Stauffer has summarized and emended Hinde's original description of this genus.

Staurocephalites acutidentatus Stauffer, 1933.

Plate II, figures 13, 14.

Staurocephalites acutidentatus Stauffer, 1933, Bull. Geol. Soc. Amer., 44: 1207, pl. 60, fig. 31.

Jaw, oblong, flattened, thin, upper edge covered by a series of 20 to 21 backward-pointing teeth, slightly longer at the anterior end. Teeth are slender, short, and rather blunt.

To this description should be added: Ventral surface

open, myocoele extending into denticles. Anterior end of dentary usually curved slightly.

Dental formula: $\frac{10-30}{1s-30m}$.

Dimensions: figured jaw, length .6 mm., width .3 mm.

Remarks: Considerable variation in length of specimens is noted, but all have similar dental formulae. Wider spacing, or variation in number of denticles do not seem to be of specific importance, so all are here assigned to the one species.

Genus Ungulites Stauffer, 1933.

Ungulites Stauffer, 1933, Bull. Geol. Soc. Amer., 44: 1201.

Established to include a group of clawlike denticles of irregular appearance.

Several specimens have been found which could be assigned to this genus, but all are so fragmentary as to make specific identification difficult. The forms observed bear one, two, or three large, clawlike teeth, but the margins are so fragmentary that the original outline of the jaw cannot be reconstructed.

EXPLANATION OF PLATE I

(All figures x 18 unless otherwise marked)

Figure

1. Arabellites arcus var. torta Gries, n. sp., ventral view.
2. Same, dorsal view
3. Grubia bifurca Gries, n. sp., dorsal view.
4. Same, ventral view.
5. Nereidavus grinnelli Croneis and Scott, dorsal view.
6. Same, ventral view.
7. Arabellites extensus Hinde, ventral view.
8. Same, dorsal view.
9. Nereidavus extensus Gries, n. sp., dorsal view.
10. Same, ventral view.
11. Nereidavus glenwoodensis Stauffer, ventral view.
12. Same, dorsal view.
13. Arabellites cornutus Hinde, dorsal view.
14. Same, ventral view.
15. Grinnellia quadrata Hinde, ventral view. (x 12)
16. Same, dorsal view. (x 12)
17. Grubia robusta Gries, n. sp., dorsal view.
18. Same, ventral view.
19. Grubia nodosa Gries, n. sp., dorsal view.
20. Same, ventral view.
21. Arabellites arcus Gries, n. sp., ventral view.
22. Same, dorsal view.
23. Grubia extenuata Gries, n. sp., dorsal view.
24. Same, ventral view.

PLATE I



EXPLANATION OF PLATE II

(All figures x 18 unless otherwise marked)

Figure

1. Paleoleodice spinosa Gries, n. sp., dorsal view. (x 20)
2. Same, ventral view. (x 20)
3. Elmhurstia nododentata Potter, ventral view.
4. Same, dorsal view.
5. Paleoleodice irregularis Gries, n. sp., dorsal view.
6. Same, ventral view.
7. Paleoleodice lunatus (Hinde), ventral view.
8. Same, dorsal view.
9. Staufferia spinosa Gries, n. sp., dorsal view.
10. Same. ventral view.
11. Paleoleodice concavus Gries, n. sp., dorsal view. (x 20)
12. Same, ventral view. (x 20)
13. Staurocephalites acutidentatus Stauffer, dorsal view.
14. Same, ventral view.
15. Paleoleodice spicatus Gries, n. sp., ventral view.
16. Same, dorsal view.
17. Clelandia trigonalis Gries, n. sp., ventral view.
18. Same, dorsal view.
19. Paleoleodice crenulatus (Hinde), dorsal view.
20. Same, ventral view.
21. Grinnellia varians Gries, n. sp., ventral view
22. Same, dorsal view.
23. Scottia ovata Potter.

24. Scottia ovata Potter, other side.
25. Paleoleodice lunatus (Hinde), dorsal view, showing wear.
26. Nereidavus compressus Gries, n. sp., dorsal view.
27. Same. ventral view.
28. Hyalinaecites coronatus Gries, n. sp., dorsal view.
29. Same, ventral view.
30. Grubia hindei (James), dorsal view.
31. Same, ventral view.
32. Grubia contorta Gries, n. sp., ventral view.
33. Same, dorsal view.
34. Grinnellia scutellata (Hinde), ventral view.
35. Same, dorsal view.
36. Paleoleodice cervicornis (Hinde), showing small denticle between second and third large denticles. Ventral view.
37. Same, dorsal view.
38. Paleoleodice cervicornis (Hinde), ventral view.
39. Same, dorsal view.
40. Paleoleodice aciculatus (James), dorsal view.
41. Same, ventral view.
42. Paleoleodice alternata Gries, n. sp., dorsal view.
43. Same, ventral view.
44. Staufferia plena (Stauffer), dorsal view.
45. Same. ventral view.
46. Clelandia recurvata Gries, n. sp., ventral view.
47. Same, dorsal view.

PLATE II



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